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Especial interest attaches to the first star on the list, whose proper motion of  $8''.7$  of arc per year is the greatest hitherto observed. It is believed that the radial velocities of C. Z. 5<sup>h</sup> 243 and Lacaille 8362 are the largest observed up to date. KAPTEYN has pointed out that, of stars with considerable proper motion, there is a considerable preponderance of the later stellar types. A number of these stars have not hitherto been observed spectroscopically, and it is of interest to note that thus far in the investigation no case has occurred of a spectrum of the hydrogen or helium type.

During February and March, 1909, considerable time was devoted to securing an extended series of spectrographic and photographic observations of Comet MOREHOUSE.

The one-prism instrument has been employed by Mr. PADDOCK to secure data for the study of several southern variable stars.

Dr. J. H. MOORE arrived in Santiago to take charge of the station on June 5, 1909, and the writer left for California on June 17th, after three and a half years spent in Santiago. It is a pleasure to be able to express here my appreciation of the uniform courtesy and interest manifested by the Government of Chile and by the people of Santiago in the work of the D. O. Mills Expedition. A list of those who have at one time or another thus shown their interest in the expedition is here unnecessary, for I found no department of the government or the municipality of Santiago that was not ready at all times to render any possible assistance. Santiago is a cosmopolitan city of nearly four hundred thousand inhabitants, including about five thousand French, perhaps ten thousand Germans, and a growing colony of about eight hundred English and Americans; there is probably no city south of the equator more pleasant as a place of residence as regards both climatic conditions and social advantages.

HEBER D. CURTIS,

*In charge of D. O. Mills Expedition, 1906-09.*

#### ON THE SPECTRUM OF *MARS*.

When the spectrum of *Mars* was under observation extensively at Mount Hamilton in 1894, for the purpose of detecting the presence of water vapor in that planet's atmosphere, I

realized that the water vapor in the Earth's atmosphere was and is the great obstacle in the way of success; and I then resolved to observe the spectrum of *Mars* from the summit of Mount Whitney<sup>1</sup>, the highest point of land in the United States, when the planet should again come into a position favorable for the purpose. This would occur in August-September, 1909, when *Mars* would be near the Earth and high above the horizon at the time of year when Mount Whitney could be ascended with instruments.

Late in August, 1908, I ascended Mount Whitney, in order to determine the limiting sizes of instruments which could be transported over the rocky trail on the backs of pack animals, and to plan the living arrangements for the proposed expedition of 1909. I was accompanied by Director C. G. ABBOT, of the Smithsonian Institution Observatory, who was interested in the summit of Mount Whitney in connection with high-altitude studies of solar radiation, as Professor LANGLEY's pioneer expedition had been interested in 1881. We remained on the summit throughout the night of August 24, 1908. The readings of the dry- and wet-bulb thermometers obtained by Director ABBOT indicated that the conditions were extremely favorable for the solution of the proposed problem. Before leaving the summit I decided definitely that observations in 1909, requiring a residence of a week or more, should not be undertaken unless a building of some kind could be erected as a shelter in case of storm; and the question of ways and means was discussed. Director ABBOT suggested that the purposes of such a building might perhaps come within the scope of the Hodgkins Funds of the Smithsonian Institution. A few weeks later, after receiving my description of a building which would meet the needs of the proposed expedition, he was pleased to present the subject to Dr. C. D. WALCOTT, Secretary of the Smithsonian Institution, for consideration. Through the Secretary's lively interest, an appropriation to provide the building for the shelter of the 1909 and any worthy future expeditions was made.

As soon as the shelter was assured, Honorable WILLIAM H. CROCKER, Regent of the University of California, made gen-

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<sup>1</sup> In the Sierra Nevada Mountains, California. Longitude, 118° 18' W.; latitude, +36° 35'; altitude, 4,420 meters (14,501 feet).

erous private provision for all the expenses of the expedition from the Lick Observatory, University of California, including such pieces of new apparatus as were required to complete the equipment. This expedition was on the summit of Mount Whitney from August 28 to September 4, 1909. The instruments consisted of a 16-inch horizontal reflecting telescope and a suitable spectroscope. The observations, made on the nights of September 1st and 2d, were mainly photographic.

The building erected by the Smithsonian Institution, under the supervision of Mr. G. F. MARSH, a public-spirited citizen of Lone Pine, was finished on the morning of our arrival. Its outside dimensions are eleven feet by thirty feet, and it is divided into three rooms. It has walls of stone and cement, doors and roof of steel, and windows of steel and wired-plate glass. No wood or other perishable material was used in its construction. The Crocker Expedition had abundant reason to appreciate the protection afforded by the building, as severe storms were encountered on the summit.

Water vapor in the atmosphere of any planet causes dark bands to be formed at certain definite positions in the spectrum of that planet; conspicuous bands if the water vapor is abundant; inconspicuous bands if the quantity is slight, as this, the only method known, is not a sensitive one.

The observer of *Mars* must look up through the Earth's atmosphere; and the great quantity of water vapor in our atmosphere, if the observer is near sea level or at ordinary altitudes, blots out the effect of any Martian vapor, making a solution of the problem impossible. By ascending Mount Whitney, altitude 14,501 feet, the Crocker Expedition placed itself above probably four-fifths or more of the Earth's water vapor. Further, the air on Mount Whitney was astonishingly dry during the time of the observations. With barometer  $17\frac{2}{3}$  inches, air temperature  $29^{\circ}$  Fahrenheit, and wet thermometer  $17^{\circ}$ , students of the atmosphere will recognize that the observers of *Mars* were looking through remarkably little terrestrial water vapor. Even this small quantity would be almost fatal to success if we did not have a fairly satisfactory method of eliminating its effects, as follows: Our Moon has no appreciable atmosphere. The lunar and Martian spectra will be affected alike by the water vapor in the earth's atmosphere.

These spectra are photographed, one immediately after the other while the conditions in our atmosphere remain unchanged, and with the Moon and *Mars* at the same altitude above the horizon so that their rays traverse equal paths in our atmosphere. If the vapor bands in the Martian spectrum are found to be stronger than in the lunar spectrum, *Mars* has water vapor in considerable quantities. If the bands in the two spectra are estimated to be equally strong, water vapor on *Mars* does not exist in sufficient quantities to be detected by the spectroscopic method. The latter condition was found to exist, when this method was applied under the superlatively favorable conditions existing on Mount Whitney. Both spectra were photographed when *Mars* and the Moon were near the horizon, again when they were at medium altitudes, and finally when they were  $49^{\circ}$  above the horizon. The best available vapor band, technically called "*a*," was faint in both spectra when the bodies were low, fainter when the bodies were higher, and very faint when the bodies were at their highest; but for equal altitudes the "*a*" bands in the Martian and lunar spectra were equally intense, plainly signifying that the observed bands were due to water vapor in the Earth's atmosphere above the summit of Mount Whitney. This does not mean that *Mars* has no water vapor, but only that the quantity present, if any, must be very slight. Let us recall that we see *Mars* by reflected sunlight. The rays which reached our instruments passed from the Sun into the Martian atmosphere, for the most part down to the surface of the planet, and then out again to us, thus passing twice through the planet's atmosphere and any water vapor it may contain. Even with this multiplying effect on *Mars* the vapor bands in the Martian and lunar spectra were alike, and we conclude that any water vapor in the Martian atmosphere must have been less extensive than was contained in the rarified and remarkably dry air strata above Mount Whitney.

A detailed account of the Crocker Expedition, including descriptions of the spectra as photographed, and a discussion of the results obtained are in press as a *Lick Observatory Bulletin*.

The members of the party were Director W. W. CAMPBELL, Assistant Astronomer SEBASTIAN ALBRECHT, and Carpenter HOOVER, of Lick Observatory; Dr. JOHN J. MILLER, of San

Jose, who took charge of all questions relating to health; and Messrs. G. F. MARSH and W. L. SKINNER, of Lone Pine, California.

W. W. CAMPBELL.

NOTE ON THE MAGNETIC FIELD IN SUN-SPOTS.

In a preliminary note printed in *Publications of the Astronomical Society of the Pacific*, 20, 220, 1908, it was shown that the evidence then available indicated the existence of a strong magnetic field in sun-spots. A summary of the results hitherto obtained in this investigation is given below:—

(1) In the spectra of sun-spots most of the Fraunhofer lines are widened, some are changed to doublets (incompletely resolved quadruplets), and some to triplets. Others probably have a still more complex structure.

(2) The component lines of spot doublets are circularly polarized in opposite directions (longitudinal effect in a magnetic field).

(3) Many lines not resolved in the spot spectrum are displaced when the Nicol (used with a Fresnel rhomb before the spectrograph slit) is rotated.

(4) When the Nicol, used with rhomb, is set at a certain angle, it transmits the red components of doublets in the spectrum of a right-handed vortex, and the violet components in a left-handed vortex.

(5) Although the larger spots in the northern and southern hemispheres of the Sun are usually found to be of opposite polarity, it frequently happens that spots of opposite polarity occur in the same hemisphere, sometimes in the same spot group.

(6) Triplets have been found in all our best photographs of spot spectra, including those taken when the spot was near the center of the Sun.

(7) The central component of such triplets is plane polarized, while the outer components are elliptically polarized.

(8) Many lines which are widened but not resolved in spot spectra can be shown to be triplets by cutting out the central component with a Nicol placed at a suitable angle.

(9) Under certain conditions, when a Nicol is used, the central line of a spot triplet is present on one side of the spot